

Chemical Basis of Life

Module A Anchor 2

Key Concepts:

- Water is a polar molecule. Therefore, it is able to form multiple hydrogen bonds, which account for many of its special properties.
- Water's polarity gives it the ability to dissolve both ionic compounds and other polar molecules.
- Carbon can bond with many elements, including hydrogen, oxygen, phosphorus, sulfur, and nitrogen to form the molecules of life.
- The function of macromolecules is directly related to their chemical structure.
- Living things use carbohydrates as their main source of energy. Plants, some animals, and other organisms also use carbohydrates for structural purposes.
- Lipids can be used to store energy. Some lipids are important parts of biological membranes and waterproof coverings.
- Nucleic acids store and transmit hereditary, or genetic, information.
- Some proteins control the rate of reactions and regulate cell processes. Some proteins build tissues such as bone and muscle. Others transport materials or help fight disease.
- Chemical reactions always involve changes in the chemical bonds that join atoms in compounds.
- Chemical reactions that release energy often occur spontaneously. Chemical reactions that absorb energy will not occur without a source of energy.
- Enzymes speed up chemical reactions that take place in cells. This function is directly related to their structure, with each enzyme being specifically shaped to catalyze one particular reaction. Loss of structure causes loss of function.
- Temperature, pH, and regulatory molecules can affect the activity of enzymes.

Vocabulary:

Hydrogen bond	solution	pH scale	cohesion
Adhesion	polarity	freezing point	monomer
Heat of vaporization	polymer	nucleic acid	nucleotide
Carbohydrate	monosaccharide	polysaccharide	lipid
Triglyceride	phospholipid	steroid	wax
Fatty acid	protein	amino acid	primary structure
Secondary structure	tertiary structure	quaternary structure	chemical reaction
Enzyme	catalyst	activation energy	active site
Substrate	product	reactant	

Properties of Water:

1. Describe the following properties of water and explain how each is important to living things: cohesion, adhesion, polarity, heat of vaporization, freezing point.

2. How is polarity related to cohesion and adhesion?

3. Compared to most other substances, a great deal of heat is needed to raise the temperature of water by a given amount. This is because water
 - A. is an acid
 - B. readily forms solutions
 - C. has a high heat capacity
 - D. acts as a buffer

4. Frozen water is less dense than liquid water. Explain why this is important for aquatic organisms.

Macromolecules:

1. How is the structure of carbon related to its function in macromolecules? Think about the types of shapes carbon can form and why.

2. Describe the processes of hydrolysis and dehydration synthesis. How are they related to each other?

3. List and draw the monomer and polymer units of each macromolecule along with their function in living things: carbohydrates, proteins, nucleic acids.

5. List and draw the types of lipids, along with the subunits and uses of each.

6. Why are carbohydrates, proteins, and nucleic acids considered polymers, while lipids are not?

7. How is the structure of each of the four macromolecules related to its function in living things?

Carbohydrate -

Nucleic acid -

Protein -

Lipid -

8. How does the structure of a protein make it capable of such a large range of function?

Enzymes:

1. What occurs during a chemical reaction?

2. What is the difference between a product and a reactant?

3. Energy is used differently in different types of chemical reactions. Explain how energy use differs in energy-releasing and energy-absorbing reactions. Which type often requires a catalyst?

How is energy related to the products and reactants of a chemical reaction?

4. What is the role of an enzyme in living organisms?

5. In what way do enzymes increase the rate of reactions? How do enzymes accomplish this task?

6. Describe the cycle in which enzymes and substrate interact.

7. How/Why is the structure of an enzyme so important to its function in living things? Why does the structure of an enzyme determine the type of reaction it will catalyze?

8. What happens to enzyme function when the temperature or pH conditions change? Why?

9. The energy needed to get a reaction started is the:

- | | |
|----------------------|--------------------|
| A. adhesion energy | C. cohesion energy |
| B. activation energy | D. chemical energy |

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Properties of Water:

1. Describe the following properties of water and explain how each is important to living things: cohesion, adhesion, polarity, heat of vaporization, freezing point.

Cohesion – attraction between molecules of the same substance, water bonds to water

Adhesion – attraction between molecules of different substances, water bonds to another Molecule

Cohesion and adhesion help life in a variety of ways: they aid in the transport of liquids in plants, provide surface tension for aquatic organisms, etc.

Polarity – Polar molecules have ends with opposite charges. The oxygen atom of a water molecule more strongly attracts the electrons involved in the covalent bonds between oxygen and hydrogen. This gives the oxygen a slight negative charge and the hydrogen a slight positive charge. The polar nature of water makes it the universal solvent.

Heat of vaporization – it takes a large amount of energy to change the state of water. This benefits aquatic organisms, as bodies of water maintain fairly stable temperature conditions.

2. How is polarity related to cohesion and adhesion?

The attraction between molecules that causes cohesion and adhesion is the result of polarity.

Polarity creates molecules with charged ends. Opposite charges attract, causing cohesion and adhesion.

3. Compared to most other substances, a great deal of heat is needed to raise the temperature of water by a given amount. This is because water

C. has a high heat capacity

4. Frozen water is less dense than liquid water. Explain why this is important for aquatic organisms.

Frozen water floats, create a buffer for aquatic organisms in winter. This buffer prevents the entire body of water from freezing and killing the organisms within it.

Macromolecules:

1. How is the structure of carbon related to its function in macromolecules? Think about the types of shapes carbon can form and why.

Carbon atoms have four valence electrons. This allows them to form strong covalent bonds with a number of elements. Carbon can also bond with itself, allowing it to form long chains or rings of carbon atoms.

2. Describe the processes of hydrolysis and dehydration synthesis. How are they related to each other?

Hydrolysis – molecules are broken into smaller pieces. Water is added.

Dehydration synthesis – oxygen and hydrogen are removed from two molecules, opening up bonding sites where they can join. The oxygen and hydrogen are joined to form water.

They are opposite processes.

3. List and draw the monomer and polymer units of each macromolecule along with their function in living things: carbohydrates, proteins, nucleic acids.

*Carbohydrate – monomer: monosaccharide polymer: polysaccharide
function: energy and structure*

*Protein – monomer: amino acid polymer: polypeptide
function – highly varied*

*Nucleic acid – monomer: nucleotide polymer: nucleic acid
function: store and transmit hereditary information*

5. List and draw the types of lipids, along with the subunits and uses of each.

Phospholipid – consists of fatty acid, phosphate group, glycerol, used in cell membranes

Wax – subunits are alcohol and fatty acids, used in structure and water-proofing

Steroid – carbon-ring structure, used as chemical messenger

Triglyceride – subunits are glycerol and three fatty acids, used for energy storage

6. Why are carbohydrates, proteins, and nucleic acids considered polymers, while lipids are not?
Carbohydrates, proteins, and nucleic acids are all composed of one repeating subunit. Lipids have a variety of subunits, and are grouped only by their shared nonpolar nature.

7. How is the structure of each of the four macromolecules related to its function in living things?

Carbohydrate – Energy is stored in bonds. Carbohydrates contain large numbers of bonds.

Nucleic acid – Nucleic acids are well-suited to store information in the repeating sequences of their base pairs. They are also structured to split and replicate easily, allowing the genetic information to be easily passed on to offspring.

Protein – Proteins have 20 different amino acids, which can be arranged in any order. Proteins also have four levels of structure: primary, secondary, tertiary, and quaternary. An alteration in any of these levels alters the function of the protein. This allows for a large variety of function.

Lipid – Lipids are nonpolar, allowing them to function in cell membranes and waterproofing. Triglycerides contain large numbers of bonds, making them ideal for energy storage.

8. How does the structure of a protein make it capable of such a large range of function?
Proteins have 20 different amino acids, which can be arranged in any order. Proteins also have four levels of structure: primary, secondary, tertiary, and quaternary. An alteration in any of these levels alters the function of the protein. This allows for a large variety of function.

Enzymes:

1. What occurs during a chemical reaction?

Bonds are broken and reformed; atoms are rearranged.

2. What is the difference between a product and a reactant?

Reactants go in to a chemical reaction; products are formed by a chemical reaction.

3. Energy is used differently in different types of chemical reactions. Explain how energy use differs in energy-releasing and energy-absorbing reactions. Which type often requires a catalyst?
Energy-releasing reactions produce more energy than they require to start, therefore they generally occur spontaneously

Energy-absorbing reactions require more energy to start than they produce, often requiring large amounts of activation energy. This often necessitates a catalyst.

How is energy related to the products and reactants of a chemical reaction?

Energy is required to break apart the reactants and to form the products.

4. What is the role of an enzyme in living organisms?

Enzymes act as biological catalysts.

5. In what way do enzymes increase the rate of reactions? How do enzymes accomplish this task?

Enzymes provide a location for the reaction to occur. They lower the activation energy needed to start the reaction, allowing it to occur more quickly.

6. Describe the cycle in which enzymes and substrate interact.

Substrate bonds to the active site of the enzyme. The reaction occurs, converting substrate/reactant into product. The product is then released. The active site of the enzyme is left unchanged. This allows the enzyme to continuously catalyze reactions.

7. How/Why is the structure of an enzyme so important to its function in living things? Why does the structure of an enzyme determine the type of reaction it will catalyze?

The active site of an enzyme is specifically shaped to hold only one specific set of substrates. Enzymes are therefore substrate specific, meaning they will only catalyze one type of reaction. If the active site of an enzyme is not designed for a particular substrate, it will not catalyze that reaction.

8. What happens to enzyme function when the temperature or pH conditions change? Why?

Changes in temperature or pH can cause denaturation of the enzyme, changing the shape of the active site and destroying the function.

9. The energy needed to get a reaction started is the:

B. activation energy